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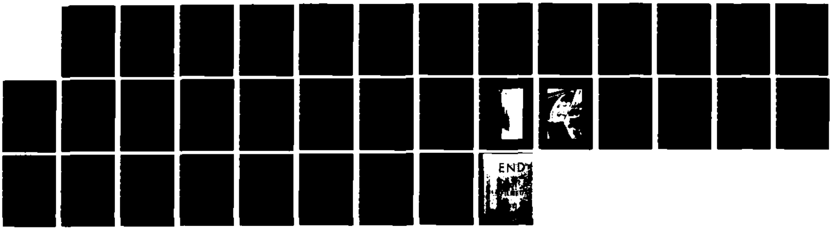

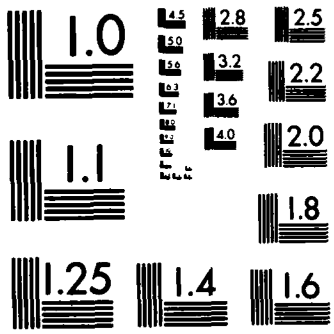

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EVALUATION OF THE EFFECTS OF LATERAL AND LONGITUDINAL APERIODIC MODES ON HELICOPTER INSTRUMENT FLIGHT HANDLING QUALITIES

by

S. R. M. Sinclair, S. Kereliuk

National Aeronautical Establishment

AERONAUTICAL NOTE
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OTTAWA
JULY 1983

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EVALUATION OF THE EFFECTS OF LATERAL AND LONGITUDINAL APERIODIC MODES ON HELICOPTER INSTRUMENT FLIGHT HANDLING QUALITIES

ÉVALUATION DES EFFETS DES MODES APÉRIODIQUES LATÉRAUX ET LONGITUDINAUX SUR LES QUALITÉS DE PILOTAGE AUX INSTRUMENTS DES HÉLICOPTÈRES

by/par

S.R.M. Sinclair, S. Kereliuk

National Aeronautical Establishment

OTTAWA
JULY 1983

AERONAUTICAL NOTE
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Laboratoire des recherches en vol

G.M. Lindberg
Director/Directeur

SUMMARY

This report describes a part of a larger program funded jointly by the US Federal Aviation Administration and the National Aeronautical Establishment to provide background information on instrument flight handling qualities of helicopter. This latest series of tests was aimed at addressing the acceptability of pitch and roll aperiodic characteristics when performing general handling and mission-oriented tasks in the NAE Airborne Simulator.

In general, the results of these tests are consistent with proposed requirements for helicopter IFR handling qualities. Two significant factors were highlighted in these tests: aircraft characteristics which were not specifically under study may have affected pilot opinions; and changes in pilot opinion occurred depending on whether the task was one of general handling or was specifically mission-oriented.

RÉSUMÉ

Le présent rapport décrit une partie d'un important programme subventionné conjointement par l'US Federal Aviation Administration et l'Établissement national d'aéronautique et visant à fournir de l'information de base sur les qualités de pilotage aux instruments des hélicoptères. Cette dernière série d'essais avait pour but de déterminer si les caractéristiques apériodiques de roulis et de tangage sont acceptables lorsqu'on effectue dans le simulateur aéroporté de l'ÉNA des manoeuvres générales et des manoeuvres dans le cadre d'une mission.

En général, les résultats de ces essais sont en accord avec les exigences proposées concernant les qualités de pilotage aux instruments des hélicoptères. Deux facteurs importants ressortent de ces essais: les caractéristiques des appareils qui n'étaient pas visées par l'étude ont pu influer sur l'opinion des pilotes; et les opinions des pilotes différaient selon qu'il s'agissait de manoeuvres générales ou de manoeuvres dans le cadre d'une mission.

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ILLUSTRATIONS (Cont'd)

EVALUATION OF THE EFFECTS OF LATERAL AND LONGITUDINAL APERIODIC MODES ON HELICOPTER INSTRUMENT FLIGHT HANDLING QUALITIES

1.0 INTRODUCTION

The formulation of instrument flight handling qualities criteria for helicopters has lagged those established for fixed-wing aircraft for a number of reasons. The utility of helicopters in their specialized tasks was not affected by limiting operations to visual flight only, to the extent that their fixed-wing counterparts would have been affected. Furthermore, stability and control characteristics which are desirable in slow speed manoeuvring flight and during hover are not always compatible with those required in cruising flight, especially when in instrument flight conditions.

In recent years, a strong demand has developed to expand civil helicopter operations into the instrument flight environment, to the extent that a new generation of helicopters has been designed for instrument flight.

Instrument flight handling qualities criteria for civil operation have been published as supplementary requirements to those demanded for visual flight, namely the "Interim Standards for Helicopter IFR Certification" (Ref. 1). As part of a review of these requirements, the US Federal Aviation Administration (FAA) published a "Rotorcraft Regulatory Review Program, Notice No. 1" (Ref. 2) on 18 December 1980 as a prelude to incorporating helicopter IFR handling qualities criteria into revised versions of FAR's 27 and 29.

The experiments described in this report were part of a larger program (Ref. 3) jointly funded by the FAA and the National Aeronautical Establishment (NAE) to provide background information on instrument flight handling qualities for helicopters. This latest series of tests was aimed at addressing the acceptability of aperiodic dynamic stability characteristics. Tentative requirements for these characteristics were defined in Reference 2 as:

a) For single pilot approval - "Any oscillation having a period of 20 seconds or more or any aperiodic response may not achieve double amplitude in less than 20 seconds", and

b) For helicopters approved with a minimum crew of two pilots - "Any oscillation having a period of 10 seconds or more or any aperiodic response may not achieve double amplitude in less than 10 seconds".

2.0 THE AIRBORNE SIMULATOR

The experiments described herein were performed using the NAE Airborne Simulator (Fig. 1), an extensively modified Bell Model 205A-1 helicopter. In converting the aircraft to its airborne simulator configuration the standard hydraulically-boosted mechanical control actuators have been replaced with a set of dual-mode electrohydraulic actuators. The electro-mechanical servo valves can drive the actuators in a conventional power-boost mode in response to mechanical signals from the conventional stick, pedals and collective lever at the left seat, or in a full-authority electric mode from the right-seat fly-by-wire station. Electric controllers and the electric actuators of the fly-by-wire system are integrated with a set of motion sensors, a hybrid computing system and a variable control-force feel system to provide the simulator with a flexible and powerful aircraft

simulation capability. A description of these systems can be found in Reference 4.

Two additional alterations have been made to the Bell 205 control systems of the simulator: the stabilizer bar has been removed, and the longitudinal-cyclic-to-elevator link has been disconnected to accommodate an electrohydraulic actuator which allows operation of the elevator as part of the fly-by-wire system. The effects of the stabilizer bar removal (an improvement in cyclic control channel bandwidth and reduction in inherent roll and pitch damping) have only an indirect influence on the operation of the simulator; use of the "electric" elevator was, on the other hand, of primary importance in modelling the combinations of longitudinal static and dynamic characteristics which were of interest in this program.

The layout of the evaluation pilot's cockpit for the instrument flying qualities experiments is shown in Figure 2, where the conventional helicopter cyclic stick, collective lever and anti-torque pedal arrangement can be seen. Selection and control functions for the guidance, navigation and communication systems were accessible for left hand operation. The guidance and navigation aids which were available to the evaluation pilot for the instrument flight tasks included an ADF receiver with bearing pointer displayed on a conventional Radio Magnetic Indicator (RMI), a VOR/ILS receiver with localizer and glideslope information indicated on an Omni Bearing Selector (OBS), and a Microwave Landing System (MLS) receiver. The MLS provided localizer and variable-gradient glideslope information which was displayed in the form of raw signals adjacent to the Main Attitude display.

3.0 MODELLING

In order to direct the evaluation pilot's attention primarily to the characteristics in question, the desired control response and dynamic characteristics were implemented in the presence of "improved" other Bell 205A characteristics using the response feedback technique. This modelling approach had the advantage of providing the well known Bell 205 characteristics as a background for the variable characteristics of the experiments.

Control force-feel was altered somewhat to provide self centring in the cyclic controls and tail rotor pedals. Both longitudinal and lateral cyclic controls required one pound breakout force and had a gradient of one pound force per inch of travel. The tail rotor pedals had only sufficient breakout and gradient to insure a tendency to return to neutral. Electric trimming was provided for the cyclic and tail rotor controls.

3.1 Lateral-Directional Tests

Table 1 lists the augmented derivatives used in the program, with models 1 to 4 inclusive simulating increasing amounts of roll spiral instability, from 14 seconds to 4 seconds time to double amplitude. In order to direct the evaluation pilot's attention to this particular characteristic, some lateral and directional stiffening (L_v, N_v) was employed and additional rate damping (L_p, N_r) used to ensure that the dutch roll characteristics would not be distracting. The longitudinal characteristics were improved by increasing static stability (M_u) from 0.25 inch stick deflection for 10 kts speed change to approx. 0.4 inches per 10 knots.

Pitch rate damping ($M_{\dot{\theta}}$), was also increased and changes in the rolling moment due to yaw rate (L_r) allowed accurate and predictable variations in the roll spiral mode instability. A time history of one example of this instability is included in Figure 3. For the lateral-directional cases, time to double amplitude was taken from 10 degrees to 20 degrees bank angle following disturbance in roll attitude.

3.2 Longitudinal Tests

Longitudinal aperiodic divergences were modelled in the presence of good lateral-directional characteristics. Lateral-directional stiffening and rate damping were used as for the roll spiral tests, but L_r was returned to the basic Bell 205 value, giving satisfactory roll spiral stabiltiy.

An attempt was made to model divergent longitudinal modes by decreasing static longitudinal stability to negative values. A satisfactory range of divergent rates could be implemented; however this technique was unacceptable due to a lack of repeatability in rates of divergence. This problem was overcome by reducing static longitudinal stability (M_u) until it was qualitatively just positive and implementing a pitching moment due to longitudinal acceleration by driving the elevator with a derivative of forward velocity ($M_{\dot{u}}$). Addition of this characteristic had no apparent effect on the longitudinal short period mode, while it provided a repeatable range of pitch divergences from 14 sec. to 4 sec. time to double amplitude. Models 5 to 8 inclusive in Table 1 outline the pertinent derivatives used. Figure 3 shows a time history of one pitch aperiodic divergence. To avoid undesirable exaggerated pitch attitudes, the time to double amplitude in this case was taken from 5 degrees to 10 degrees pitch angle following a disturbance in pitch attitude.

3.3 Lateral/Longitudinal Divergences

For Model 9 the L_r and $M_{\dot{u}}$ terms were adjusted to provide simultaneous roll and pitch aperiodic divergences reaching double amplitude in 8 seconds.

4.0 EVALUATION TASKS

Conventional helicopter handling characteristics usually include asymmetries, cross-coupling and non-linearities to varying degrees. These may dominate pilot opinion to the extent that effects of variations in some test characteristics may well be masked. In attempting to reduce this masking effect, it was essential that each evaluation pilot be familar with the basic Bell 205 handling qualities, in particular the inherent asymmetries and cross-coupled control and response characteristics which were common to all the models. Each evaluation pilot was therefore allowed up to 3 hours familiarization flying in the unaugmented Bell 205. During this inital training period, the pilot also gained familiarity with the evaluation task and rated the acceptability of the unaugmented Bell 205 characteristics.

Any investigation into handling qualities for instrument flight must consider the available crew complement. In this experiment, an attempt was made to emphasize the difference between a two pilot operation, where one pilot performs only the "hands-on" control task with an additional crew member performing all auxiliary tasks, and a single pilot operation where a lone crewman performs all tasks. Previous experiments in Reference 3 addressed this requirement by providing separate tasks for single-pilot and two-pilot evaluations. However, in this experiment the pilot was asked to perform a single-pilot task and to subjectively extrapolate his assessment to the two-pilot situations.

4.1 Preliminary Flight Test Task

The evaluation pilots were briefed on the characteristics of each configuration and asked to perform a "general handling" assessment as listed in Figure 4 while in full knowledge of the configuration they were flying. A sample questionnaire for this task is included in Figure 5. The evaluation in question 3 of this questionnaire was purely subjective requiring extrapolation to the real world environment from this limited "hands-on" task. An expanded definition of the recommendations in question 3, included as Figure 6, was issued to each pilot.

4.2 Operational Task

A mission-oriented task was flown where the pilot was asked to perform the following task elements: copy and repeat approach clearances, select the appropriate approach plate, tune-in the required navigational facilities, navigate the circuit and perform the necessary radio calls, track on 6 degree MLS precision approach to minimum, and perform an overshoot and missed approach procedure with the required radio calls, clearance acknowledgements and navigational procedures. During this portion of the evaluation, the pilot was not fore-warned of the configuration he was flying or of which of six approach procedures he was to perform. (A sample approach plate is included in Figure 7.) On completion of each task, a questionnaire, included in Figure 8, was completed. The evaluator was asked to rate the workload and the performance of the task using the Cooper-Harper rating scale. Although this task represented a single pilot situation, the evaluator was also asked to subjectively adjust his rating to the situation where an additional crew member would be present to perform all non-control tasks. Comments on the stability and control characteristics of each configuration were required to support the ratings.

The final portion of the questionnaire requested a certification-related assessment as expanded in Figure 6.

5.0 EVALUATIONS

Evaluations were performed by one airworthiness test pilot from Transport Canada and three research pilots from the National Aeronautical Establishment for a total of approximately 30 flight hours. Relevant experience of the evaluators is listed in Table 2. (Note that pilot D was not available to evaluate any configurations with pitch divergent characteristics.)

The augmentation of the background stability and control characteristics - those characteristics which were not of direct interest in this study - did not entirely eliminate their influence upon the assessments of the various models. All evaluation pilots, for example, complained about the inherent cross-coupling evident in all configurations, the dominant ones being heave to yaw, pitch and roll as in previous tests (Ref. 3). Workload associated with cross-coupled control and response may have dominated pilot opinion of the models during glide-slope intercept and on initiation of the overshoot procedure. Even though longitudinal static stability was augmented in models 1 to 4 to levels approaching moderate as defined in Reference 3, one evaluation pilot felt that the speed stability for these models was very low and in fact dominated his opinion of the flying qualities. At the same time this pilot requested a faster longitudinal cyclic trimmer rate and a steeper longitudinal stick force gradient. Another evaluator felt that longitudinal deficiencies made lateral-directional considerations of secondary concern for these same four configurations. The main criticisms were: poor short-term response in the controlled longitudinal variables to changes in

pitch attitude, poor pitch attitude retention, and extremely high long-term sensitivity of airspeed to pitch attitude. The remaining two evaluators felt that the longitudinal handling qualities of these first four configurations were satisfactory and did not affect workload to any appreciable extent. On the other hand, when evaluating configurations with longitudinal aperiodic divergences (Models 5 to 8 incl.) all of the subject pilots felt that the lateral-directional characteristics were satisfactory and not a factor in the evaluations.

5.1 Lateral Aperiodic Divergent Modes

Results of the lateral aperiodic certification assessments are plotted in the form of histograms in Figure 9 both for the preliminary flight test task where the pertinent characteristics were known to the pilot during the assessment and for the operational task where the pilot was not informed of the configuration he was flying. In comparing these results, it should be noted that the question to be answered (Fig. 5, Question 3) during the preliminary task was not as stringent a commitment as during the operational task (Fig. 8, Question C(1)).

Results in Fig. 9 indicate that the degradation in handling qualities when the roll spiral mode was destabilized was more noticeable in the preliminary flight test task than in the operational task. This may have been in part due to the fact that evaluators were aware of the characteristics they were investigating in the preliminary task. Also, the fact that the evaluator could devote his total attention to the characteristics in question in the preliminary task may have had a bearing on the results.

The certification assessments indicated in these histograms are further interpreted in Table 3. In view of the operational task assessment, for single pilot operation, lateral aperiodic divergences reaching double amplitude in 14 seconds or less may not be acceptable. This result falls into line with the requirements in Reference 3 (Para 1 (a)(b)). On the other hand, for two-pilot operation, divergences reaching double amplitude in down to 6 seconds, somewhat more rapid divergences than acceptable in Reference 3, proved acceptable.

5.2 Longitudinal Divergent Modes

Histograms of the longitudinal aperiodic certification assessments are included in Fig. 10. Contrary to the evidence in paragraph 5.1 for the lateral divergences, the operational task certification assessments of the longitudinal divergences indicate a clearer picture of handling qualities degradation than that shown in the preliminary flight test task. The longitudinal deficiencies appeared more obvious to the evaluators during the operational task and were evidenced as poor attitude stability making speed control a dominant factor in the pilot workload. The results of the task-oriented evaluations indicated that aircraft with divergent aperiodic pitch rates reaching double amplitude in 14 seconds should not be considered for single-pilot IFR. In fact, some measure of attitude or speed stability would probably be required. Table 3 summarizes these results.

5.3 Combined Lateral and Longitudinal Divergent Modes

Histograms in Figure 11 show the results of evaluations for Model 9, the configuration which provided simultaneous divergences in pitch and roll reaching double amplitude in 8 seconds. Comparison of these histograms with the corresponding single-axis divergences in Figures 9 and 10 indicates that pilot opinion degraded further when both pitch and roll axis were destabilized. It is doubtful whether this configuration would be considered acceptable for 2 pilot IFR.

5.4 Bell 205 Baseline Evaluation

Figure 12 is a histogram indicating the results of the operational task evaluations after each evaluator completed his familiarization training with the basic Bell 205A configuration. It was evident that this aircraft would not be considered suitable for instrument flight.

6.0 CONCLUDING REMARKS

The results of these tests reflect in a general sense the proposed requirements for helicopter IFR handling qualities, although most of the evaluators were willing to accept slightly more rapid aperiodic divergent rates than those specified in the proposed requirements. This acquiescence in a large part may be due to the improvements in the baseline characteristics of the aircraft. The level to which these background characteristics should be maintained must be addressed in future programs, for it is unlikely that an aircraft meeting a bare minimum in all qualities would in fact be acceptable.

Another philosophical factor in the determination of handling qualities criteria was also evident in these results. The conglomerate of control and auxiliary sub tasks, representing an operational situation as closely as possible, allowed the evaluators to view specific characteristics within the total picture of the task, environment and the vehicle, a view not readily available when doing general handling tests. In order to assure reliable results, mission - oriented tasks may well be required for the formulation of handling qualities criteria.

7.0 ACKNOWLEDGEMENT

The following test pilots participated in this experiment:

L. Galvin	Transport Canada
S. Kereliuk	NAE
J.M. Morgan	NAE
D.E. Sattler	NAE

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2. Rotorcraft Regulatory Review. Program Notice No. 1. Federal Aviation Administration, December 1980.

3. Sinclair, Kereliuk — Evaluations of Helicotper Instrument Flight Handling Qualities, NAE LR-608, Jan. 1982.

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TABLE 1

	CONSTANT					VARIABLE			
MODEL	L_p rps^2/rps	L_v rps^2/fps	N_r rps^2/rps	N_v rps^2/fps	$M_{\dot{\theta}}$ rps^2/rps	M_u rps^2/fps	$M_{\dot{u}}$ $(T_{2\theta})$	L_r $(T_{2\phi})$	
BASIC 205	-0.81	-0.013	-1.3	0.023	-0.45	0.003	—	0.17	BASELINE
1	-1.79	-0.021	-2.24	0.029	-1.24	0.0045	—	-0.322 (14)	LATERAL APERIODIC
2	"	"	"	"	"	0.0045	—	-0.814 (8)	
3	"	"	"	"	"	0.0045	—	-1.306 (6)	
4	"	"	"	"	"	0.0045	—	-1.798 (4)	
5	"	"	"	"	"	0.002	0.0043 (14)	0.17	LONGITUDINAL APERIODIC
6	"	"	"	"	"	0.002	0.0086 (8)	0.17	
7	"	"	"	"	"	0.002	0.0129 (6)	0.17	
8	"	"	"	"	"	0.002	0.0172 (4)	0.17	
9	"	"	"	"	"	0.002	0.0086 (8)	-0.814 (8)	LAT/LONG APERIODIC

TABLE 2

RELEVANT PILOT EXPERIENCE (HOURS)

PILOT	TOTAL TIME	TOTAL ROTARY WING	TOTAL INSTRUMENTS
A	6500	450	1100
B	1042	399	130
C	7500	1025	1100
D	5900	3800	700

TABLE 3

SUGGESTED LIMITS BASED ON RESULTS

Upper = Based on Preliminary Flight Test Task, Lower = Based on Operated Task

	SINGLE PILOT	TWO PILOTS
LATERAL	$T_{2\phi} \geqslant 8$ sec. > 14 sec.	$T_{2\phi} \geqslant 6$ sec. $\geqslant 6$ sec.
LONGITUDINAL	$T_{2\theta} \geqslant 14$ sec. > 14 sec.	$T_{2\theta} \geqslant 8$ sec. $\geqslant 8$ sec.

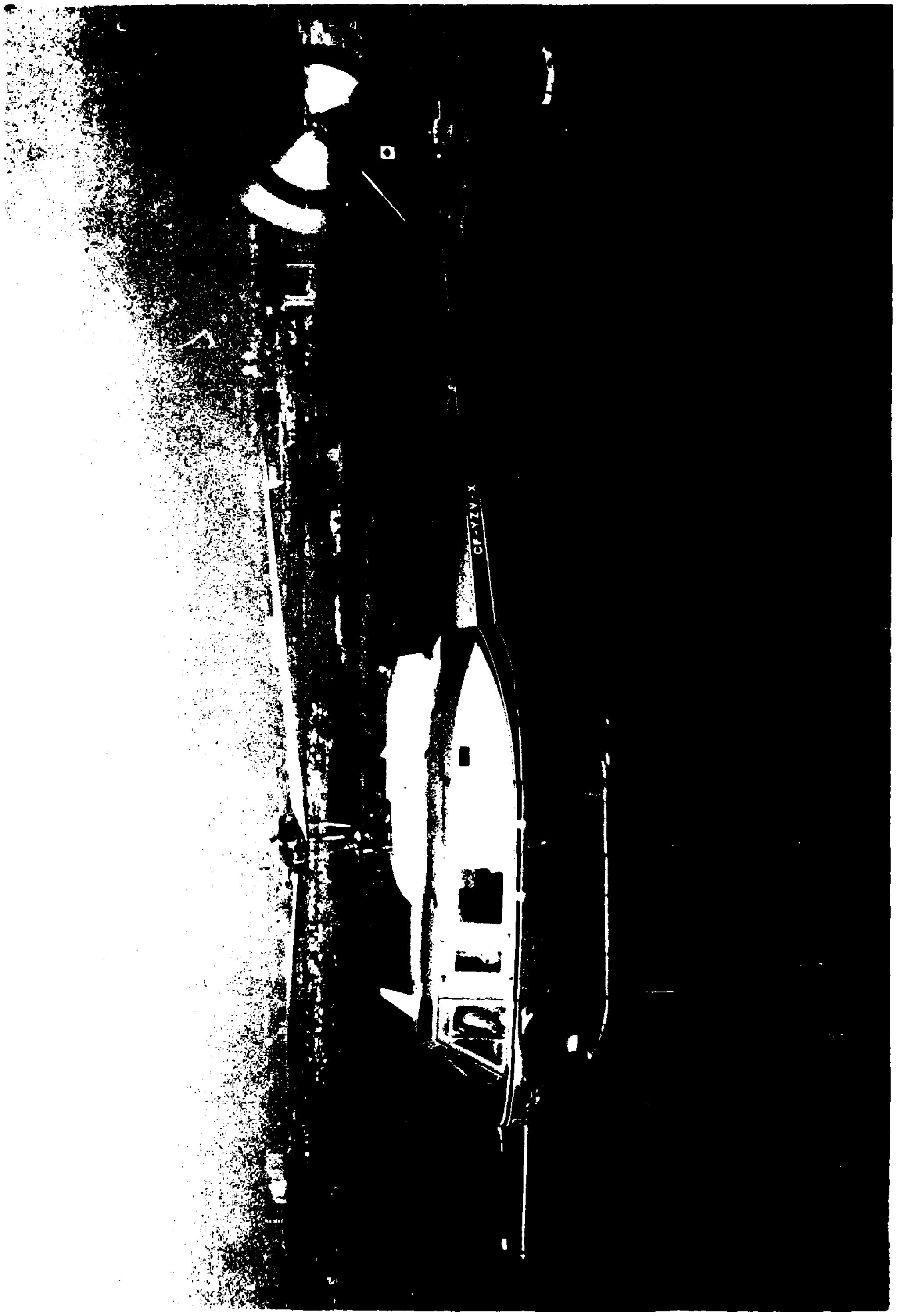


FIG. 1: NAE AIRBORNE SIMULATOR

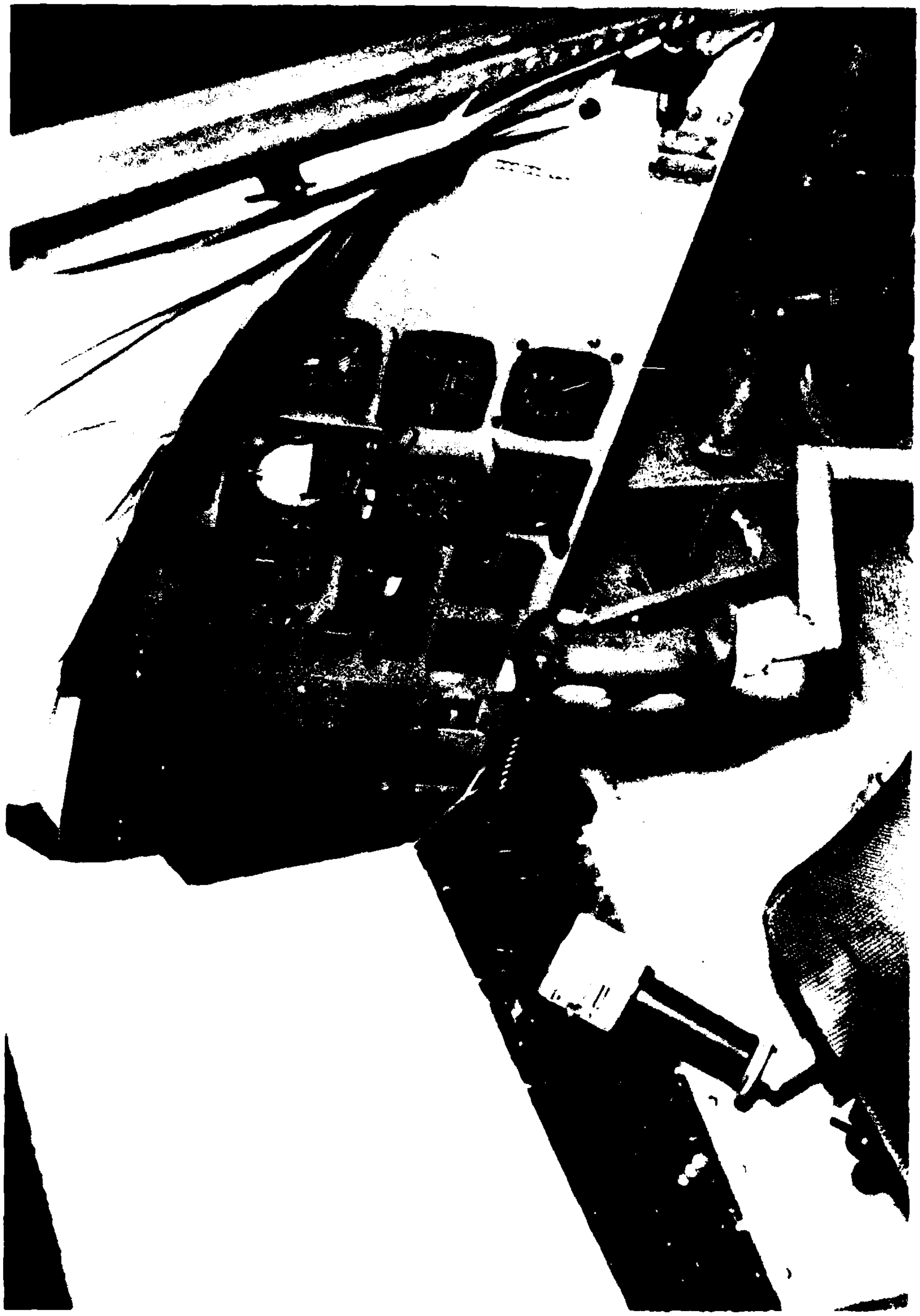
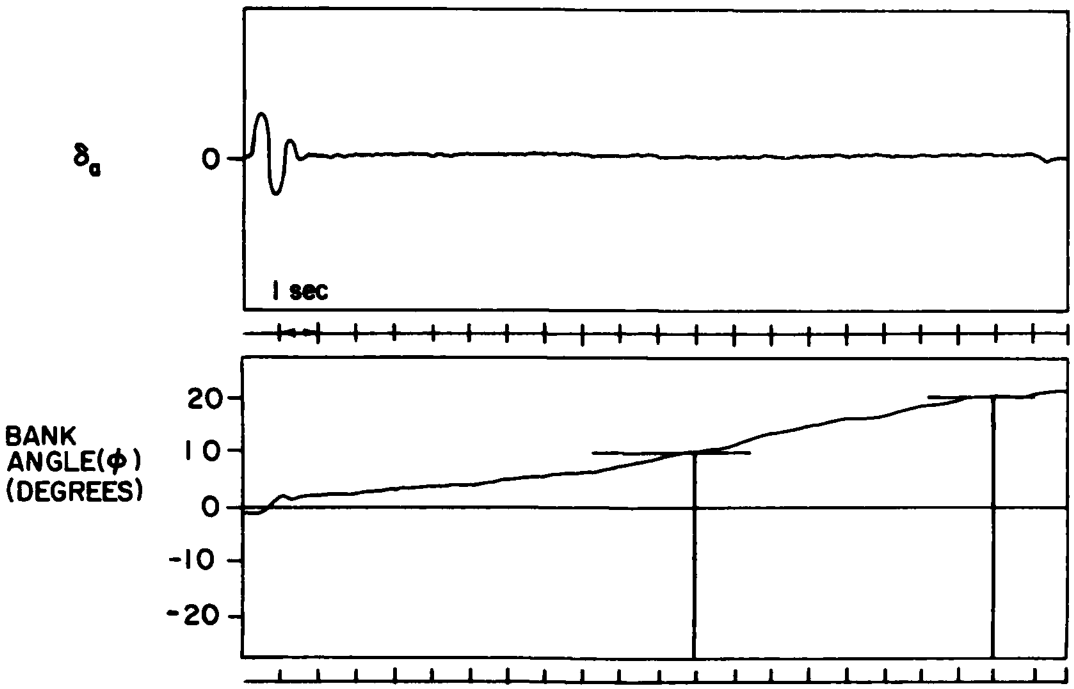
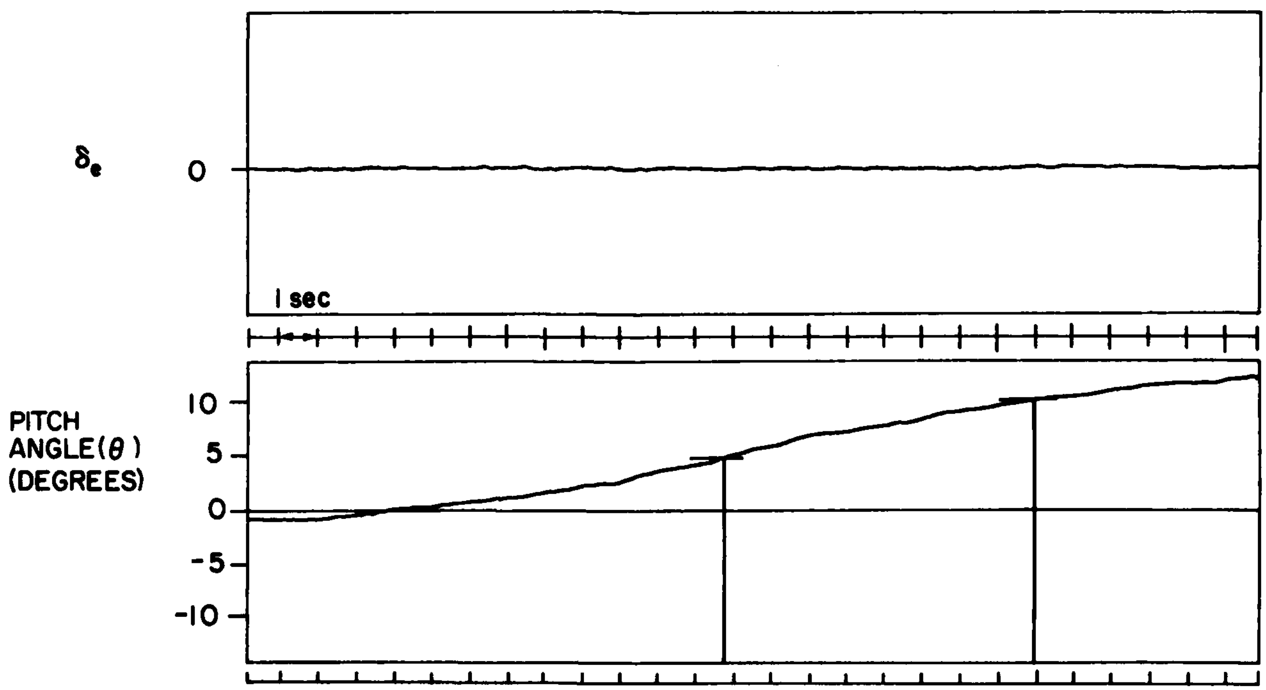


FIG. 2: EVALUATION COCKPIT



MODEL 2(9)
LATERAL DIVERGENCE



MODEL 6(9)
PITCH DIVERGENCE

FIG. 3: TIME HISTORIES

1. **DYNAMIC RESPONSE** — TRIMMED 70 KIAS STRAIGHT AND LEVEL

   a. LATERAL CYCLIC PULSES ($\Delta\phi < 10^\circ$)
      LEFT
      RIGHT

   b. LONGITUDINAL CYCLIC PULSES ($\Delta\theta < 5^\circ$)
      NOSE UP
      DOWN

   c. PEDAL PULSES ($\Delta\beta < 10^\circ$)
      LEFT
      RIGHT

   d. COLLECTIVE STEPS ($\Delta\delta c < 1''$)
      UP
      DOWN

2. **LONGITUDINAL STATIC STABILITY** — TRIMMED 70 KIAS STRAIGHT AND LEVEL

   a. 70 KIAS → 80 → 60 → 70
      CONSTANT ALTITUDE, NO TRIMMING

   b. 70 KIAS → 80 → 60 → 70
      CONSTANT ALTITUDE, NO TRIMMING

3. **TURNING MANOEUVRES** — TRIMMED 70 KIAS STRAIGHT AND LEVEL

   20 DEGREE BANK TURN RIGHT 90°

   REVERSE LEFT 90°

4. **STABILITY IN CLIMBS AND DESCENTS** — TRIMMED 70 KIAS STRAIGHT AND LEVEL

   a. ↑ 1000FPM, $\Delta h = 500'$, RETRIM

   b. ↓ 1000FPM, $\Delta h = 500'$, RETRIM

FIG. 4: GENERAL HANDLING TEST

HIFR PHASE IV – GENERAL HANDLING

PILOT: ______________________________ MODEL NO: ______________

DATE: ______________

1. Describe briefly the Stability and Control Characteristics and Handling Qualities of this Model Helicopter under the following headings:

   a. Longitudinal Static Characteristics

   b. Longitudinal Dynamic Characteristics

   c. Lateral Directional Characteristics

   d. Other Comments

2. Describe the Operational Implications of any Flying Qualities Deficiencies Identified above (with Reference to the Single-Pilot and Dual-Pilot IFR Missions)

3. Based on this brief flight test, would you recommend this helicopter for more detailed evaluation toward:

   a. Single Pilot IFR Certification ☐

   b. Two Pilot IFR Certification ☐

   c. Would not recommend for IFR Flight ☐

FIG. 5: GENERAL HANDLING QUESTIONNAIRE

BASED ON YOUR SHORT EVALUATION, IN WHICH OF THE FOLLOWING CATEGORIES WOULD YOU PLACE THIS CONFIGURATION:

1. The helicopter has excellent flying qualities and could be operated safely in a high-density IFR environment by one pilot without the assistance of additional crew members. ☐

2. The helicopter has good flying qualities and could be operated safely in a high-density IFR environment by one pilot without the assistance of additional crew members. ☐

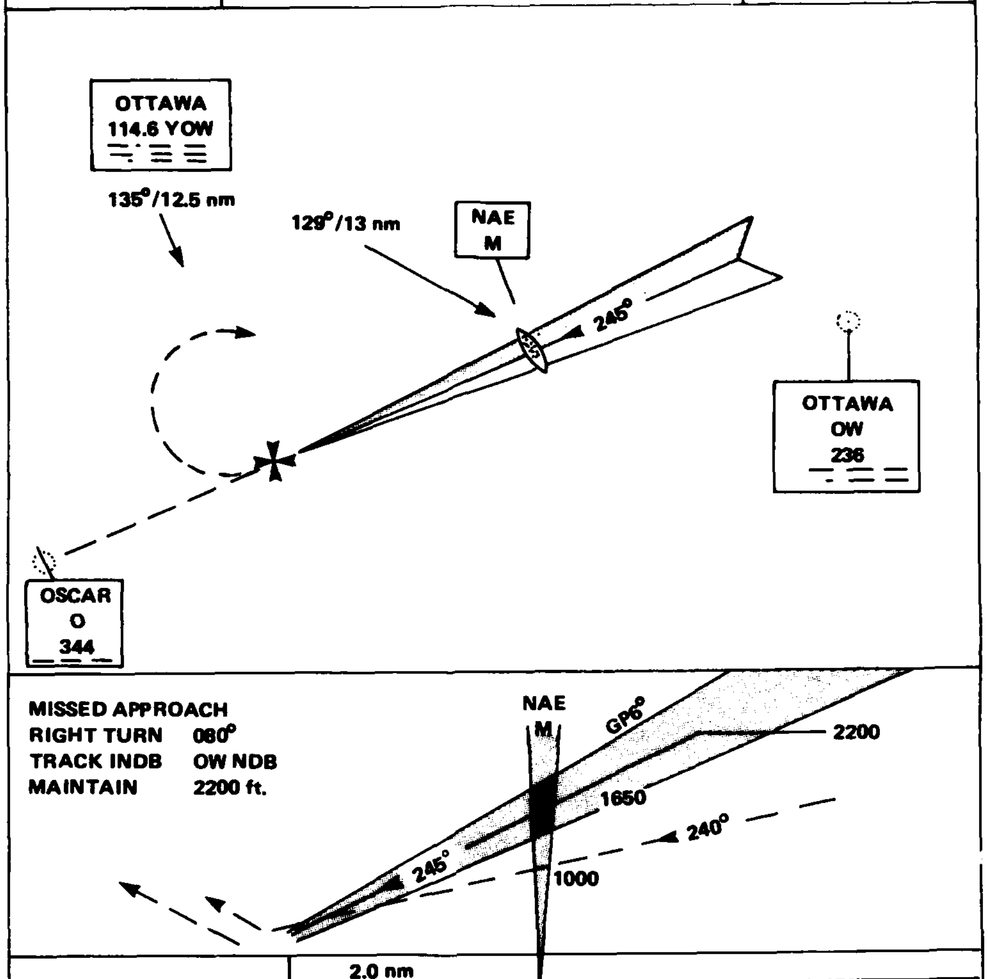
3. The helicopter has flying qualities defieiencies which make it unsuitable for single-pilot operations in a high-density IFR environment, however it could be operated safely within such an environment if the pilot-in-command were relieved of all non-control tasks by an additional qualified crew member. ☐

4. The helicopter has major flying qualities deficiencies which make it unsuitable for operation within a high-density IFR environment. ☐

FIG. 6: CERTIFICATION RELATED ASSESSMENT

MLS/NDB RWY 24 NAE

NAE APP 129.6		ELEV 400



FULL MLS	600 (200) ½ RVR 26
G/P INOP	800 (400) 1 RVR 50
AOF STR. IN	900 (500) 1 RVR 50

NAE M TO RWY 2.0 nm			
KNOTS	40	60	80
MIN:SEC	2:55	1:58	1:28

FIG. 7: SAMPLE MLS APPROACH PLATE

EVALUATION PILOT: ____________________ FLIGHT #: ____________________

CONFIGURATION #: ____________________ DATE: ____________________

WEATHER AND WINDS: ____

____

A. TWO-PILOT TASK SEQUENCE RECORDER RUN #: ____________________

1. COOPER-HARPER RATING ☐ COMPUTER GENERATED TURBULENCE: ____________________

2. Comment on distinguishing characteristics or features which support this rating:

a. LONGITUDINAL CHARACTERISTICS ____________________

b. LATERAL-DIRECTIONAL CHARACTERISTICS ____________________

c. OTHER FEATURES ____________________

FIG. 8: PILOT QUESTIONNAIRE

B. SINGLE-PILOT TASK SEQUENCE RECORDER RUN #: ______________

1. COOPER-HARPER RATING ☐ COMPUTER GENERATED TURBULENCE: ______________

2. Comment on distinguishing characteristics or features which support this rating.

a. LONGITUDINAL CHARACTERISTICS ______________

b. LATERAL-DIRECTIONAL CHARACTERISTICS ______________

c. OTHER FEATURES ______________

C. IFR CERTIFICATION LEVEL (See Extended Description of Categories)

1. EXCELLENT 1-Pilot ☐

GOOD 1-Pilot ☐

2-Pilot ☐

NOT CERTIFIABLE ☐

2. COMMENTS ______________

FIG. 8: PILOT QUESTIONNAIRE (Cont'd)

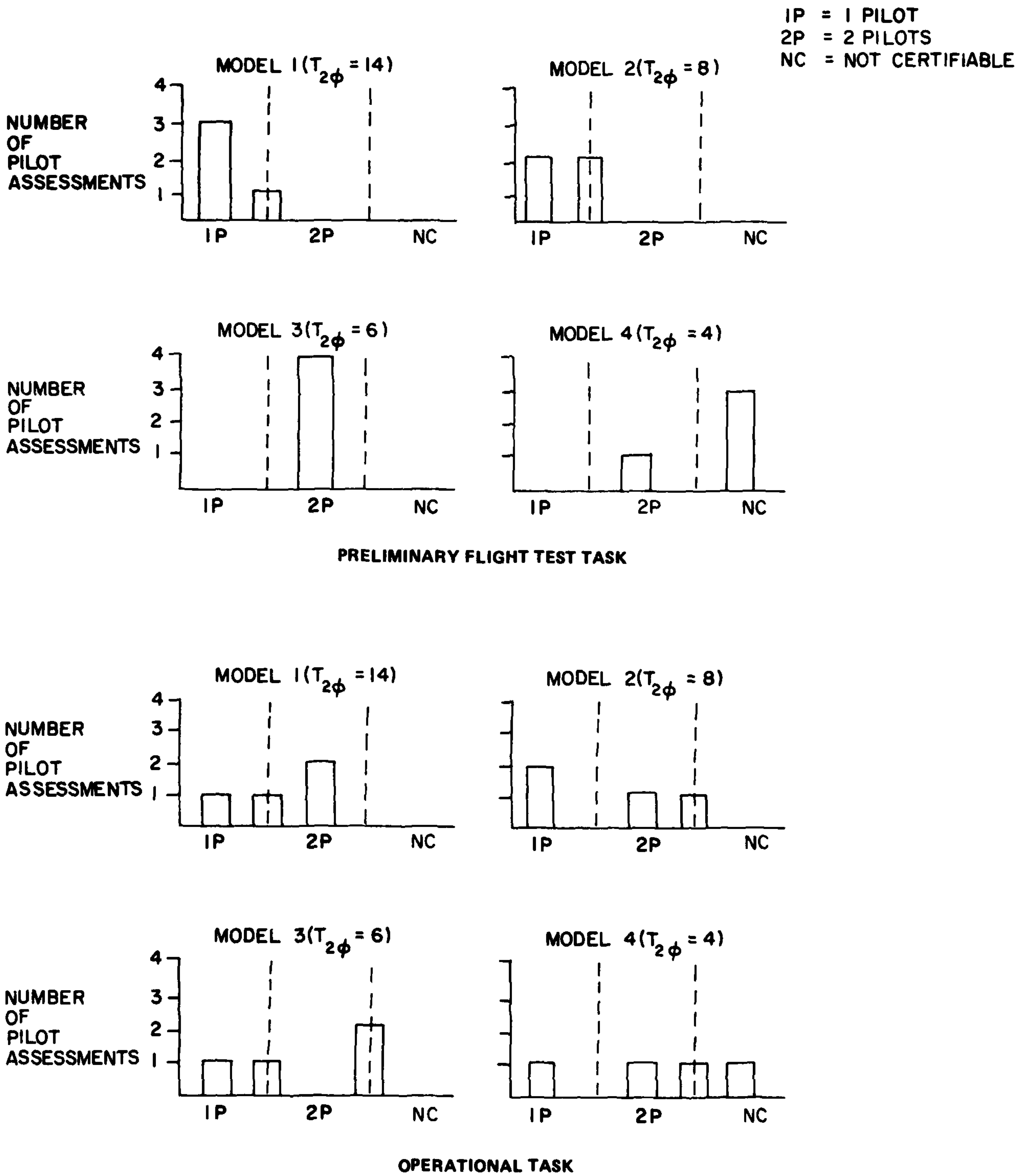


FIG. 9: LATERAL DIVERGENCE

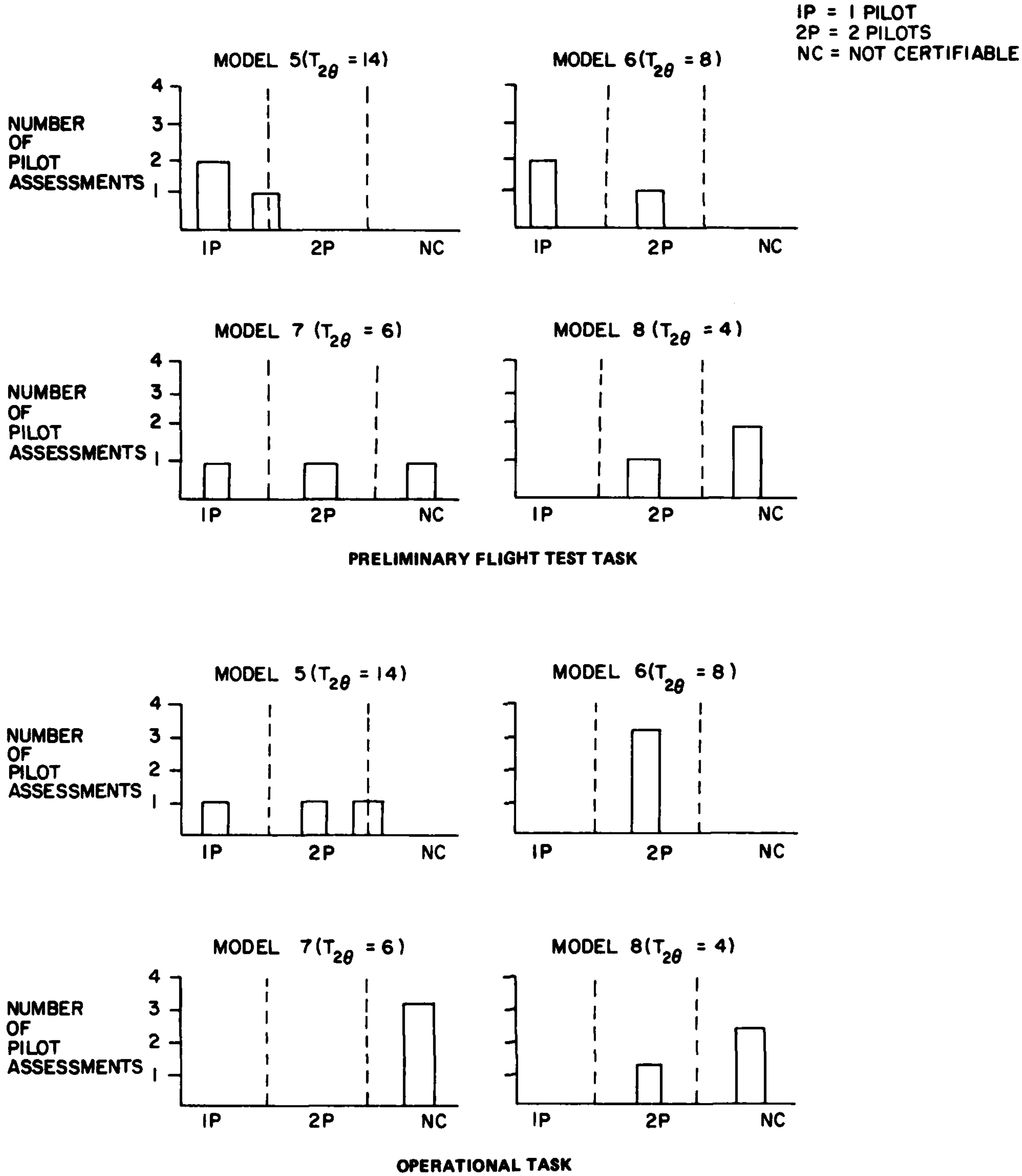
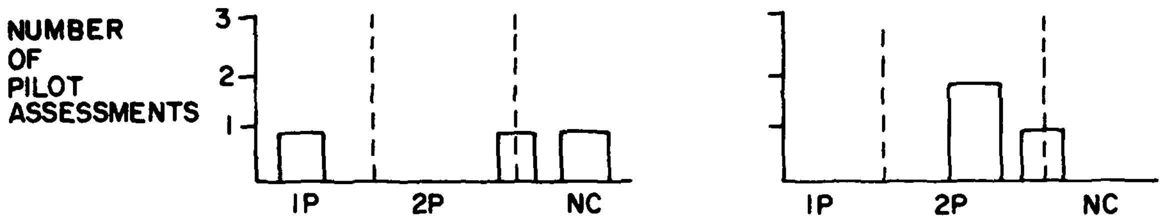


FIG. 10: LONGITUDINAL DIVERGENCE

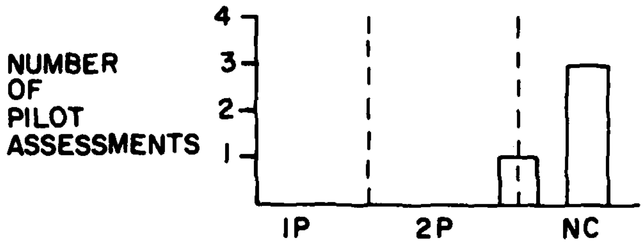


PRELIMINARY FLIGHT TEST TASK

OPERATIONAL TASK

MODEL 9
($T_{2\phi}$ & $T_{2\theta}$ = 8 sec)

FIG. 11: ROLL AND PITCH DIVERGENCE



OPERATIONAL TASK

FIG. 12: BELL 205A
(STABILIZER BAR REMOVED)

APPENDIX A

Mnemonics	Description
L_p	Roll damping moment
L_r	Rolling moment due to yaw rate
L_v	Rolling moment due to sideslip
$M_{\dot{\theta}}$	Pitching moment due to pitch attitude rate (damping)
M_u	Pitching moment due to forward speed
$M_{\dot{u}}$	Pitching moment due to longitudinal acceleration
N_r	Yawing moment due to yaw rate
N_v	Yawing moment due to sideslip
$T_{2\theta}$	Pitch attitude time to double amplitude (from 5° to 10°)
$T_{2\phi}$	Bank angle time to double amplitude (10° to 20°)

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4 Evaluation of the Effects of Lateral and Longitudinal Aperiodic Modes on Helicopter Instrument Flight Handling Qualities

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NOTES

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DESCRIPTORS (KEY WORDS)/MOTS-CLÉS

1. Helicopters — instrumentation
2. Helicopters — flight testing
3. Instrument flight — effectiveness
4. Instrument flight — simulation

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SUMMARY/SOMMAIRE

This report describes a part of a larger program funded jointly by the US Federal Aviation Administration and the National Aeronautical Establishment to provide background information on instrument flight handling qualities of helicopter. This latest series of tests was aimed at addressing the acceptability of pitch and roll aperiodic characteristics when performing general handling and mission-oriented tasks in the NAE Airborne Simulator.

In general, the results of these tests are consistent with proposed requirements for helicopter IFR handling qualities. Two significant factors were highlighted in these tests: aircraft characteristics which were not specifically under study may have affected pilot opinions; and changes in pilot opinion occurred depending on whether the task was one of general handling or was specifically mission-oriented.

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